is likely to be pin pop-through (elastic sheet), with a user-operated roller to erase tactile images. In the simplest implementation, the user writes on the back of the display with a free hand version of the tracker (roller pen described previously), and the displayed tactile image is a mirror image of what was written by the user. It is possible to employ a two-step writing process that reverses the image a second time and provides the user with a non-mirrored image to view.

All mechanical systems exposed to the environment experience wear and sometimes need repair. It is therefore important to keep in mind the ability to refurbish or repair, when designing production devices. There is significant value to the intended users in designing a tactile graphic display so that some of the repairs can be carried out by a blind or visually impaired user; this must be balanced against the complexity of various types of repair and the additional production cost associated with user-serviceable designs. Specific features that can enhance the ability to repair devices using this invention include the ability to disassemble the stack that forms the display matrix, the ability to replace worn pins, and the ability to detach the display matrix from the driving mechanism.

There are many situations in which the user may want to interact with the graphic image displayed rather than entering all commands by other methods such as voice or keyboard. Examples include the interactive addition of elements to a drawing, and clicking on graphically displayed control buttons. A number of control mechanisms have been incorporated in graphic tablets for use by sighted users, and many of these are applicable for use with a tactile graphic display. The basic requirements are position detection and sensing that an action should be taken. Position detection could be performed by incorporating pressure sensors in the display if sensitive enough to operate with the pin locking mechanisms herein disclosed. Alternatively, ultrasonic or optical pickup could be utilized. The use of a stylus simplifies the detection of a command to perform an action, but since the user reads the display with the fingertips, there may be an advantage to implementation of a system that can be controlled by a fingertip on the display. A simple example of this would be optical detection of finger position, and acoustic pickup of a fingernail clicked at a selected point on the display.

A conventional optical scanner is a useful accessory for obtaining images to be represented on the tactile graphic display. An additional possibility is a tactile scanning device that collects tactile images of real objects, for immediate display or for storage and later playback.

It is possible to use a mechanical linkage (e.g. a buckle) for the pin locking mechanism that remains stable after locking without the need to supply power. With this type of lock, the display surface is essentially independent of the display driving and control systems until it is time to unlock the pins. Therefore, the extended array tactile graphic display can be configured with a detachable display surface that maintains a stable tactile graphic image on the detached surface. This capability provides two benefits to the user. First, the user may wish to work on a project that requires simultaneous access to more tactile graphic information than can be displayed on a single display surface of the size that the user possesses. Rather than pay the price of two or more complete displays, the user can pay for one display driving system and multiple display screens (or display matrices), and write each screen in turn until all the needed information is displayed on one or another of the screens. Second, if the display surface becomes defective due to damage or wear, the user can attach a replacement screen and send the defective screen away for repair, thus minimizing the amount of time that the user does not have access to a working display.

Since the non-computer-driven extended tactile graphic array could be used as a sketchpad for hand drawing, the addition of elements to sense the positions of the pins will allow the user to connect the array to a computer system and capture the tactile image drawn, for further processing or storage.

With computer driven applications, the user can make permanent hardcopies of displayed images by attaching a commercially available tactile graphic embosser to the computer system. Examples of applications are the desire of the user to simultaneously access multiple screens of images (similar to the use of detachable screens described above), and tactile image distribution, for example handouts for a class.

In an extended array tactile graphic display, the tactile image created on the display is a real physical structure that the user reads by moving the fingers over the surface. The realism of such a display is the extent to which the user can easily receive the intended tactile impressions from the display. A primary issue is the spatial resolution of the display, which affects the user's ability to perceive lines and curves as continuous objects. If future technological advances make higher pin resolutions practical, it is likely that displays using the higher pin resolutions will provide increased functionality, including a greater sense of realism and the ability to display more detailed tactile graphic images. Similarly for multi-level displays, the number of depth levels determine the amount of relief that can realistically be portrayed.

It is fortunate that generic drawings do not have to conform to a particular scale. If there is a need for the user to feel a particular feature of an image, then the image can be scaled (or zoomed) to the point at which the feature can be displayed with the resolution available on the display. In this sense, the amount of detail that can be shown on a tactile graphic display is more a function of the total number of pins than of the pin spacing, unless the pin spacing is significantly closer than 20 pins per linear inch.

While the primary intended use of the extended array tactile graphic display is the display of images, it is expected that many users will also want the display device to show Braille text in addition, for example Braille labels on portions of a diagram. Unlike graphics, Standard Braille text has specific preferred dimensions, which can not be exactly reproduced on a tactile graphic array unless the pin spacing of the array corresponds to those dimensions. The spacing between dots in a Braille cell, the spacing between Braille cells in a row, and the spacing between rows of Braille cells are all different, so Standard Braille can not be presented on a regular rectangular array. "Dithering" displayed Braille text (shifting the pin positions or using multiple pins to map the desired dimensions of the text to the pin array) is not recommended because the relative spacing of the dots in Braille is also very important, and the user needs to be able to feel each Braille dot as a distinct point. The most effective solutions appear to be: 1) position the pins in the layout of the extended array in the proper configuration to display Braille, with additional pins as needed to obtain relatively uniform pin spacing for graphics applications (as shown in FIG. **4**), or 2) adjust the dimensions of the Braille text so that while it no longer exactly matches Standard Braille dimensions, the match is as close as can be achieved with the